What is claimed is :

1. An optical amplifier including :

an amplifier medium allowing a propagation of a signal light which is subject to an amplification, said amplifier medium being doped with at least one kind of rare-earth ions, and each of said at least one kind of rare-earth ions having an energy level system which includes :

a ground level ;

a first pair of a laser upper level and a laser lower level which is higher than said ground level and lower than said laser upper level ; and

a second pair of an excited state absorption upper level, and an excited state absorption lower level which is lower than said excited state absorption upper level, wherein said second pair allows absorbing an emission light generated by a transition from said laser upper level to said laser lower level, and wherein said excited state absorption lower level is higher than said ground level and lower than said laser upper level, and wherein said excited state absorption lower level is different from said laser lower level ;

a first excitation generator for causing a first type excitation of said at least one kind of rare-earth ions to cause a population inversion between said laser upper level and said laser lower level ; and

a second excitation generator for causing a second type excitation of said at least one kind of rare-earth ions from said excited state absorption lower level to a high excited level which is equal to or higher than said laser upper level.

2. The optical amplifier as claimed in claim 1, wherein said first type excitation is a transition of said at least one kind of rare-earth ions from said ground level to said high excited level.

3. The optical amplifier as claimed in claim 1, wherein said first excitation generator generates at least one of first type excitation lights which cause said first type excitation, and said second excitation generator generates at least one of second type excitation lights which cause said first second type excitation, and said second type excitation lights are different in wavelength from said first type excitation lights.

4. The optical amplifier as claimed in claim 1,

wherein said laser upper level includes at least one of plural different energy levels thermally coupled with each other,

wherein said laser lower level includes at least one of plural different energy levels thermally coupled with each other,

wherein said excited state absorption upper level includes at least one of plural different energy levels thermally coupled with each other, and

wherein said excited state absorption lower level includes at least

one of plural different energy levels thermally coupled with each other.

5. The optical amplifier as claimed in claim 1, wherein said amplifier medium is in a form of an optical fiber waveguide, and said optical amplifier is in a form of an optical fiber laser.

6. The optical amplifier as claimed in claim 1, wherein said amplifier medium comprises a fluorozirconate glass doped with erbium ions.

7. The optical amplifier as claimed in claim 1, wherein a base material of said amplifier medium comprises a fluorozirconate glass.

8. The optical amplifier as claimed in claim 1, wherein said at least one kind of rare-earth ions comprises erbium ions.

9. The optical amplifier as claimed in claim 8, wherein said laser upper level includes at least one of $^4S_{3/2}$, and $^2H_{11/2}$, and said laser lower level includes $^4I_{9/2}$, said excited state absorption lower level includes $^4I_{13/2}$, and said excited state absorption upper level includes $^4I_{9/2}$.

10. The optical amplifier as claimed in claim 8,

wherein said first excitation generator generates at least one of first type excitation lights, which are ranged in wavelength from 960

nanometers to 985 nanometers, and which cause said first type excitation, and

wherein said second excitation generator generates at least one of second type excitation lights, are ranged in wavelength from 780 nanometers to 790 nanometers, and which cause said first second type excitation.

11. The optical amplifier as claimed in claim 8,

wherein said first excitation generator generates at least one of first type excitation lights, which are ranged in wavelength from 795 nanometers to 805 nanometers, and which cause said first type excitation, and

wherein said second excitation generator generates at least one of second type excitation lights, are ranged in wavelength from 780 nanometers to 790 nanometers, and which cause said first second type excitation.

12. The optical amplifier as claimed in claim 8, wherein said optical amplifier includes plural optical amplifier units coupled in series with each other, and wherein each of said plural optical amplifier units further includes said amplifier medium, said first excitation generator and said second excitation generator.

13. The optical amplifier as claimed in claim 12, wherein a cut-off

device for cutting off any amplified spontaneous emission light is interposed between adjacent two of said plural optical amplifier units coupled in series with each other.

14. The optical amplifier as claimed in claim 13, wherein said cut-off device cuts off at least one of lights ranged in wavelength from 500 nanometers to 560 nanometers and from 820 nanometers to 860 nanometers.

15. The optical amplifier as claimed in claim 9, further including :

a gain enhancement generator for supplying said amplifier medium with a gain enhancement light with a wavelength which causes that a ratio S_1/S_2 of a first cross section S_1 of a transition from $^4S_{3/2}$-level to $^4I_{13/2}$-level to a second cross section S_2 of a transition from $^4I_{13/2}$-level to $^4S_{3/2}$-level is ranged from 0.2 to 2.2.

16. The optical amplifier as claimed in claim 8, wherein $(D \times L)/(S \times P)$ is ranged from 1 to 10, where D is a concentration (ppm) of said erbium ions, L is an interaction length (m) between said amplifier medium and excitation light, S is an interaction cross section (μm^2) between said amplifier medium and excitation lights, and P is a total power (mW) of said first type excitation light and said second type excitation light which are incident into said amplifier medium.

17. An optical amplifier including :

an optical fiber waveguide comprising an amplifier medium which further comprises a fluorozirconate glass doped with erbium ions having an energy level system which includes :

a ground level ;

a first pair of a laser upper level and a laser lower level which is higher than said ground level and lower than said laser upper level ; and

a second pair of an excited state absorption upper level, and an excited state absorption lower level which is lower than said excited state absorption upper level, wherein said second pair allows absorbing an emission light generated by a transition from said laser upper level to said laser lower level, and wherein said excited state absorption lower level is higher than said ground level and lower than said laser upper level, and wherein said excited state absorption lower level is different from said laser lower level ;

a first excitation generator which generates at least one of first type excitation lights which cause a first type excitation of said erbium ions to cause a population inversion between said laser upper level and said laser lower level ; and

a second excitation generator generates at least one of second type excitation lights which cause a second type excitation of said erbium

ions from said excited state absorption lower level to a high excited level which is equal to or higher than said laser upper level, wherein said second type excitation lights are different in wavelength from said first type excitation lights.

18. The optical amplifier as claimed in claim 17, wherein said laser upper level includes at least one of ${}^4S_{3/2}$, and ${}^2H_{11/2}$, and said laser lower level includes ${}^4I_{9/2}$, said excited state absorption lower level includes ${}^4I_{13/2}$, and said excited state absorption upper level includes ${}^4I_{9/2}$.

19. The optical amplifier as claimed in claim 17,

wherein said first excitation generator generates at least one of first type excitation lights, which are ranged in wavelength from 960 nanometers to 985 nanometers, and which cause said first type excitation, and

wherein said second excitation generator generates at least one of second type excitation lights, are ranged in wavelength from 780 nanometers to 790 nanometers, and which cause said first second type excitation.

20. The optical amplifier as claimed in claim 17,

wherein said first excitation generator generates at least one of first type excitation lights, which are ranged in wavelength from 795 nanometers to 805 nanometers, and which cause said first type excitation,

and

wherein said second excitation generator generates at least one of second type excitation lights, are ranged in wavelength from 780 nanometers to 790 nanometers, and which cause said first second type excitation.

21. The optical amplifier as claimed in claim 17, wherein said optical amplifier includes plural optical amplifier units coupled in series with each other, and wherein each of said plural optical amplifier units further includes said amplifier medium, said first excitation generator and said second excitation generator.

22. The optical amplifier as claimed in claim 21, wherein a cut-off device for cutting off any amplified spontaneous emission light is interposed between adjacent two of said plural optical amplifier units coupled in series with each other.

23. The optical amplifier as claimed in claim 22, wherein said cut-off device cuts off at least one of lights ranged in wavelength from 500 nanometers to 560 nanometers and from 820 nanometers to 860 nanometers.

24. The optical amplifier as claimed in claim 17, further including :

a gain enhancement generator for supplying said amplifier

medium with a gain enhancement light with a wavelength which causes that a ratio S_1/S_2 of a first cross section S_1 of a transition from $^4S_{3/2}$-level to $^4I_{13/2}$-level to a second cross section S_2 of a transition from $^4I_{13/2}$-level to $^4S_{3/2}$-level is ranged from 0.2 to 2.2.

25. The optical amplifier as claimed in claim 17, wherein $(D\times L)/(S\times P)$ is ranged from 1 to 10, where D is a concentration (ppm) of said erbium ions, L is an interaction length (m) between said amplifier medium and excitation light, S is an interaction cross section (μ m^2) between said amplifier medium and excitation light, and P is a total power (mW) of said first type excitation light and said second type excitation light which are incident into said amplifier medium.

26. A method of operating an optical amplifier which includes : an amplifier medium allowing a propagation of a signal light which is subject to an amplification, said amplifier medium being doped with at least one kind of rare-earth ions, and each of said at least one kind of rare-earth ions having an energy level system which includes :

a ground level ;

a first pair of a laser upper level and a laser lower level which is higher than said ground level and lower than said laser upper level ; and

a second pair of an excited state absorption upper level, and an excited state absorption lower level

which is lower than said excited state absorption upper level, wherein said second pair allows absorbing an emission light generated by a transition from said laser upper level to said laser lower level, and wherein said excited state absorption lower level is higher than said ground level and lower than said laser upper level, and wherein said excited state absorption lower level is different from said laser lower level,

wherein said method includes :

causing a first type excitation of said at least one kind of rare-earth ions to cause a population inversion between said laser upper level and said laser lower level ; and

causing a second type excitation of said at least one kind of rare-earth ions from said excited state absorption lower level to a high excited level which is equal to or higher than said laser upper level.

27. The method as claimed in claim 26, wherein said first type excitation is a transition of said at least one kind of r are-earth ions from said ground level to said high excited level.

28. The method as claimed in claim 26, wherein said first type excitation is caused by at least one of first type excitation lights, and said first second type excitation is caused by at least one of second type excitation lights different in wavelength from said first type excitation

lights.

29. The method as claimed in claim 26,

wherein said laser upper level includes at least one of plural different energy levels thermally coupled with each other,

wherein said laser lower level includes at least one of plural different energy levels thermally coupled with each other,

wherein said excited state absorption upper level includes at least one of plural different energy levels thermally coupled with each other, and

wherein said excited state absorption lower level includes at least one of plural different energy levels thermally coupled with each other.

30. The method as claimed in claim 26, wherein said amplifier medium comprises a fluorozirconate glass doped with erbium ions.

31. The method as claimed in claim 26, wherein a base material of said amplifier medium comprises a fluorozirconate glass.

32. The method as claimed in claim 26, wherein said at least one kind of rare-earth ions comprises erbium ions.

33. The method as claimed in claim 32, wherein said laser upper level includes at least one of $^4S_{3/2}$, and $^2H_{11/2}$, and said laser lower level includes $^4I_{9/2}$, said excited state absorption lower level includes $^4I_{13/2}$, and

said excited state absorption upper level includes $^4I_{9/2}$.

34. The method as claimed in claim 28, wherein said first type excitation lights are ranged in wavelength from 960 nanometers to 985 nanometers, and said second type excitation lights are ranged in wavelength from 780 nanometers to 790 nanometers.

35. The method as claimed in claim 32, wherein said first type excitation lights are ranged in wavelength from 795 nanometers to 805 nanometers, and said second type excitation lights are ranged in wavelength from 780 nanometers to 790 nanometers.

36. The method as claimed in claim 33, further including :

supplying said amplifier medium with a gain enhancement light with a wavelength which causes that a ratio S_1/S_2 of a first cross section S_1 of a transition from $^4S_{3/2}$-level to $^4I_{13/2}$-level to a second cross section S_2 of a transition from $^4I_{13/2}$-level to $^4S_{3/2}$-level is ranged from 0.2 to 2.2.

37. The method as claimed in claim 32, wherein $(D\times L)/(S\times P)$ is ranged from 1 to 10, where D is a concentration (ppm) of said erbium ions, L is an interaction length (m) between said amplifier medium and excitation light, S is an interaction cross section (μm^2) between said amplifier medium and said excitation light, and P is a total power (mW) of said first type excitation light and said second type excitation light which

are incident into said amplifier medium.